

**BEFORE THE BOARD OF INQUIRY**

**IN THE MATTER** of the Resource  
Management Act 1991

**AND**

**IN THE MATTER** of applications for  
resource consent and  
notices of requirement  
by Transpower  
New Zealand Limited  
for the North Island  
Grid Upgrade Project

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**STATEMENT OF EVIDENCE OF ROY JOHN CLEMENT NOBLE FOR  
TRANSPOWER NEW ZEALAND LIMITED  
(Overview: transmission line engineering)**

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## INTRODUCTION

### Qualifications and role

1. **MY** name is Roy John Clement Noble. I hold the role of Team Leader (Transmission Lines) with Transpower New Zealand Limited (**Transpower**). I have undertaken the role of Transmission Line Engineering Manager for the North Island Grid Upgrade Project (**Upgrade Project**) since May 2004.
2. I hold a New Zealand Certificate of Engineering (Civil).
3. I have 22 years experience in the design, construction and maintenance of high voltage transmission lines. I have worked on line construction projects, including the Huntly to Stratford line, Haywards Substation line deviations, and Churton Park deviation projects. I have undertaken management roles on a number of reconductoring and refurbishment projects.
4. I have worked for two years as a Land Survey Technician in Saskatchewan, Canada. This work included transmission line surveying and mine, dam and legal surveys.
5. **MY** experience includes 5 years as South Island Transmission Line Maintenance Manager for a contractor to Transpower, followed by 3 years working in a transmission line design and project management consultancy.
6. I have worked for Transpower directly for 9 years, initially in an engineering support role for maintenance works, however over the last 4 years I have transitioned back into engineering design and management roles for transmission line development and enhancement projects.
7. **MY** responsibilities relating to the Upgrade Project include management of all engineering aspects of the overhead transmission line. This includes providing engineering input to all phases of the ACRE process, design and costing of options for the Grid Upgrade Plan, attendance at open days, engineering representation on the indicative alignment selection group, management of field engineering activities, engineering inputs to Notice of

Requirement (**NOR**) documentation, and management of the overhead line design.

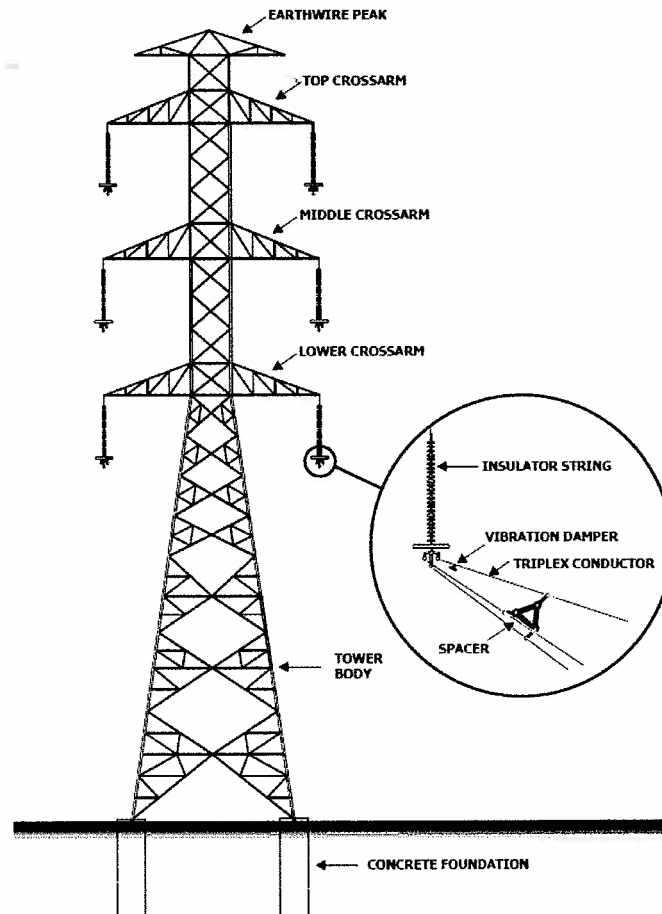
8. I confirm that I have read and am familiar with the Code of Conduct for Expert Witnesses in the Environment Court Consolidated Practice Note (2006). I have approached the preparation of this evidence in the same way that I would for the Environment Court.

#### **Scope of evidence**

9. **IN** this brief of evidence, I provide an overview of transmission line engineering. I discuss:
- (a) the basic components of an overhead transmission line;
  - (b) the development of the overhead line design;
  - (c) the principles of alignment selection and tower positioning;
  - (d) an overview of the proposed line design;
  - (e) the consideration of alternative tower heights;
  - (f) tower design status; and
  - (g) limitation on the design flexibility.
10. I provide an overview of the overhead line design from a civil, structural and electrical perspective. Mr Khot will provide detailed evidence on the electrical aspects of the transmission line design, including line rating, conductor selection, clearances, lightning performance, insulation design, audible noise, radio frequency interference, and electric and magnetic interference (**EMF**). Mr Lake will provide detailed evidence about the use of PLS-CADD in transmission line design, line behaviour, basic design parameters for the line, preliminary tower design, and foundation design.

## BASIC COMPONENTS OF AN OVERHEAD TRANSMISSION LINE

11. **OVERHEAD** transmission lines consist of four major components. These are the conductors, structures (including foundations), insulator sets, and earthwires. These are shown on the diagram below:



12. I discuss each of these components further below.

### Conductors

13. **THE** purpose of the conductors is to span from structure to structure to carry the electricity. The conductors consist of conductive wires bundled together.
14. **THE** proposed overhead line is a double circuit line, with each circuit consisting of three phases. Each phase will have a triplex sub-conductor arrangement, which means there are three conductors in a triangular configuration (two horizontally spaced at the top, and a single one positioned centrally below). Sub-conductor spacers are installed between the individual

conductors within the triplex bundle to ensure the conductors are held apart and do not clash. The details of the selection of the conductor size and bundle are discussed in Mr Khot's evidence.

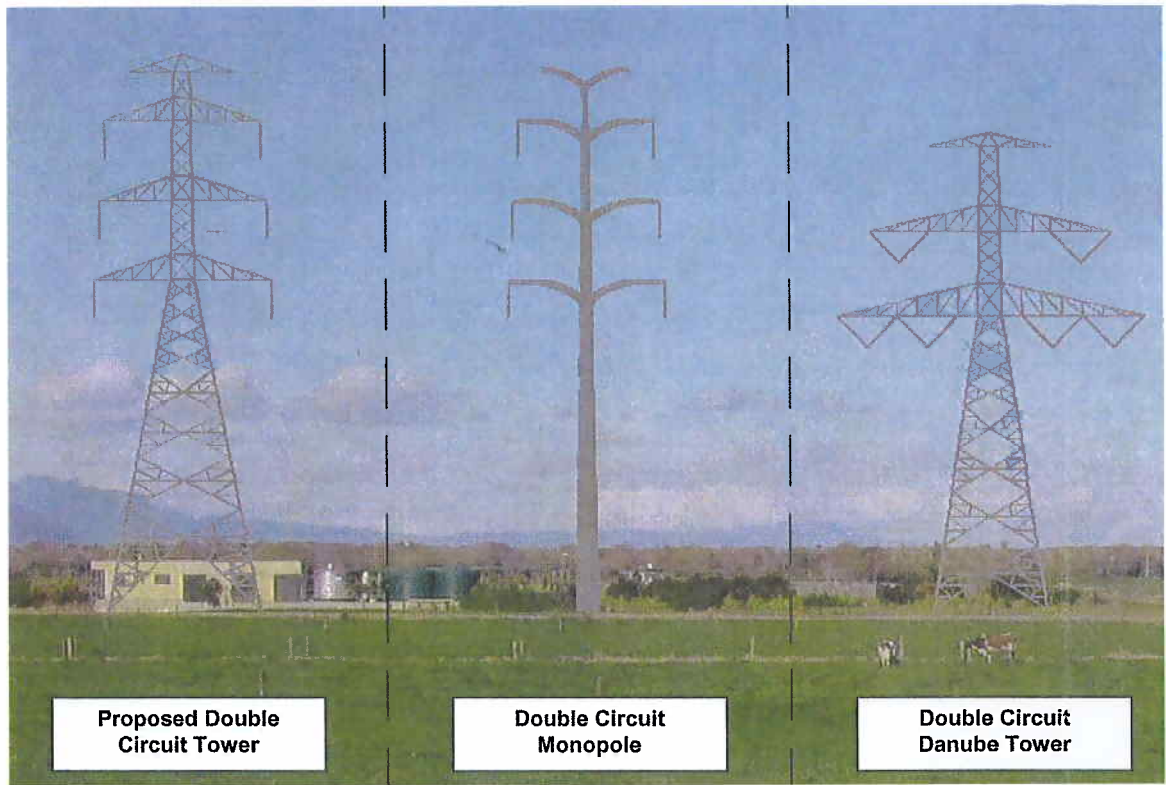
## **Structures**

15. **THE** purpose of the structure on an overhead transmission line is to support the conductors and earthwires above the ground or other obstacles to maintain safe electrical clearances. Internationally, the most common designs for 400 kV capable structures consist of self supporting lattice towers, guyed lattice structures and tubular poles. The proposed structure type for the Upgrade Project is self supporting lattice towers. The detailed reasons for this decision will be addressed later in my evidence and in Mr Lister's evidence.
16. **SELF** supporting lattice towers consist of a number of tower types (towers with different strength characteristics) to make up a tower family. This concept is used to ensure that a similar design philosophy, and common structure dimensions and scales, are maintained. The use of tower families, incorporating different tower types, provides the ability to optimise tower weights and to ensure light towers are used where loads are the least. It also generally ensures a relatively consistent visual appearance. Tower families will be discussed in more detail by Mr Lake.
17. **HIGH** voltage alternating current (**AC**) transmission line structures are designed to carry one, two or more circuits and are commonly called "single circuit structures" or "double circuit structures", etc. A double circuit structure has provision for carrying two three-phase circuits, i.e. it has a total of six conductor set support positions, as shown in the picture above.

### *Double circuit structures*

18. **THE** conventional configuration of double circuit structures in New Zealand has three phases of each circuit arranged spatially adjacent to each other and separate from the other circuit. These structures are traditionally configured so that the phases of each circuit are aligned vertically, with one circuit positioned on each side of the structure body. Alternative layouts such as the "Danube" style, shown below, are used in parts of Europe. The use of these alternative layouts would bring additional factors, such as wider easements,

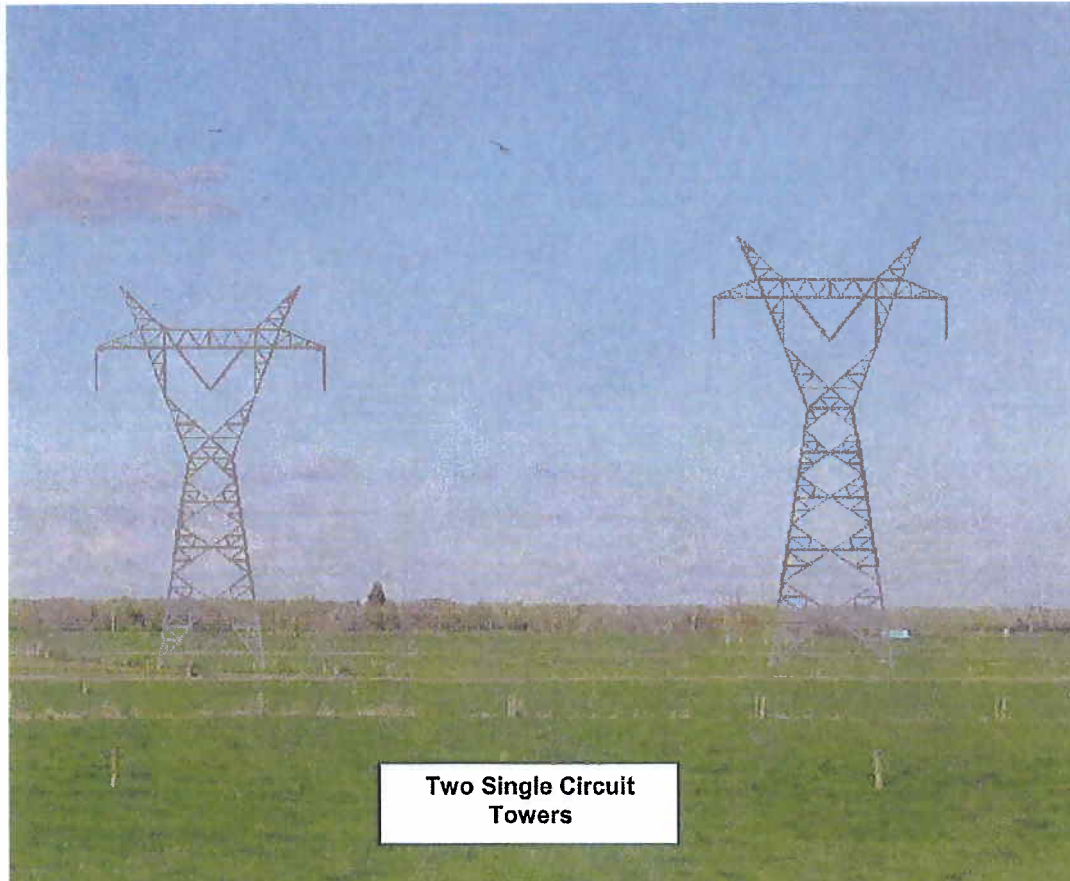
increased working clearances and changes in EMF. The proposed design specifies the use of conventional double circuit structures.



*Single circuit structures*

19. **SINGLE** circuit structures carry one three-phase circuit only (i.e. a total of three conductor set support positions).

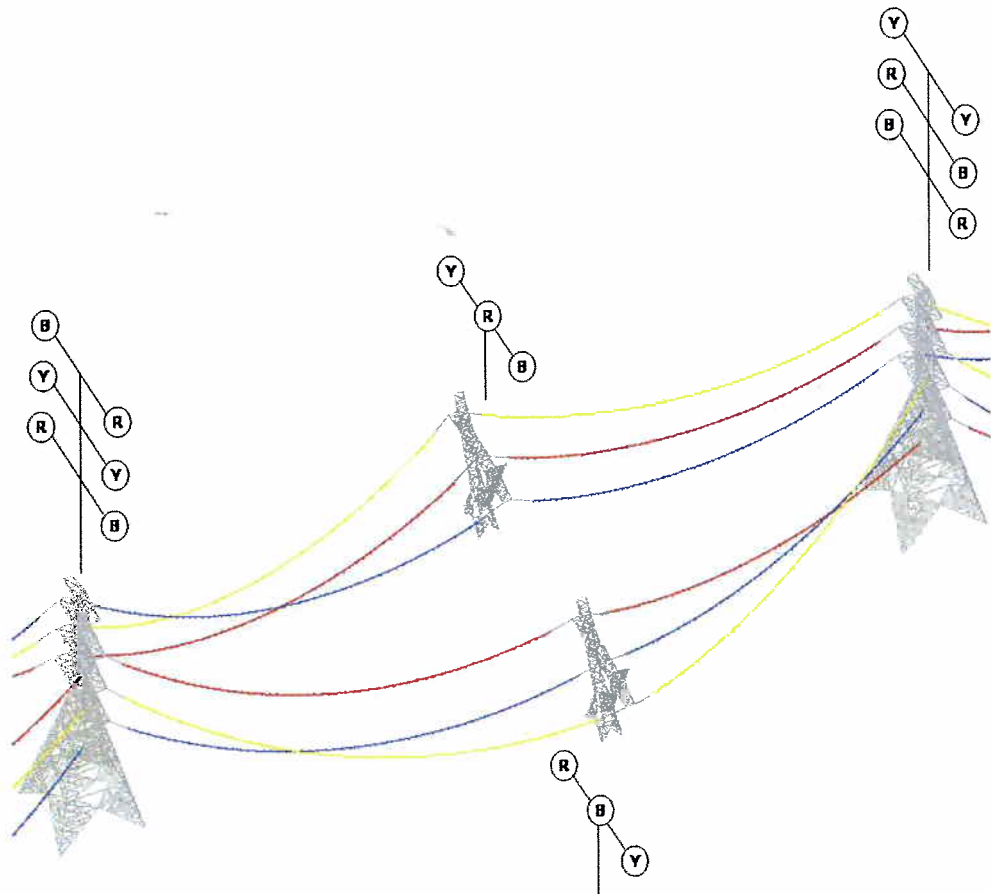
20. **THE** conventional configuration of single circuit structures in New Zealand has the three phases aligned horizontally, as shown below. The horizontal configuration of phases enables tower heights to be lowered. However, parallel single circuit towers are required to carry double circuit lines.



#### Transposition site

21. **AS** discussed in Mr Boyle's evidence, there is a requirement to have two transposition sites located at approximately third points along the proposed line. As also discussed by Mr Boyle, the purpose of these sites is to allow the phasing of the conductor to be transposed, or repositioned on the double circuit crossarms while ensuring the reverse phasing of the circuits remains in place along the full length of the proposed line. Reverse phasing is critical to reducing EMF, as discussed by Mr Khot.
22. **THE** most practical way to achieve a transposition of the conductors on a double circuit line is to transition the conductors from a double circuit tower to a single circuit structure. The conductors from this single circuit tower to the

next double circuit tower are then moved to another crossarm. This is shown in the diagram below.



23. **AS** can be seen in the diagram, the top conductor in the foreground (red) moves through the single circuit tower, and reconnects to the next double circuit tower on the lower crossarm while the conductor remains reverse phased before and after.
24. **TRANSPower** has incorporated this method of transposition in the design for the proposed line.

#### Insulator sets

25. **THE** purpose of the insulator sets is to electrically insulate the live conductors from the earthed structures so the power can flow along the conductors.
26. **EACH** phase on each tower requires an insulator set. The set consists of insulators that may be manufactured from glass, ceramic, or a composite

material, of conductors in a phase, and hardware to attach these insulators to the structure and the conductors. The number and orientation of the insulator sets depends on the structure type and conductor loading.

### **Earthwires and communications systems**

27. **THE** purpose of the earthwire is to bond all the structures together and protect the conductors from lightning strikes. Earthwires can also serve as a communication system by utilising an internal optical fibre groundwire that provides signalling for protection systems, and a communication link between substations.
28. **THE** proposed overhead line includes two earthwires, one of which will be an optical fibre groundwire.

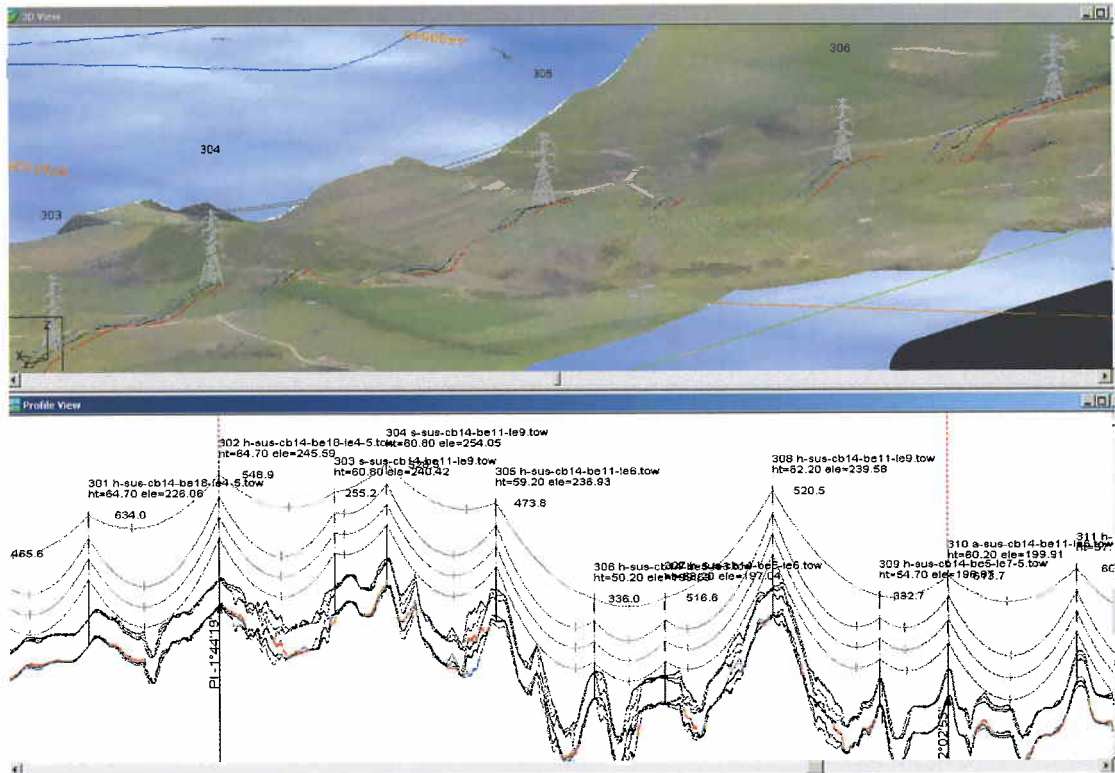
### **DEVELOPMENT OF THE OVERHEAD LINE DESIGN**

29. **THE** specification for the initial line design was set in 2004. This specification called for a 1200MVA per circuit capable line for submission of the original Grid Upgrade Plan. In 2006 this circuit capability increased to 2700MVA as part of Transpower's supplementary Grid Upgrade Plan.
30. **THE** development of an overhead transmission line design starts with the selection of a structure type and a conductor. The type of structure chosen, including the height, is a function of the operating voltage, tower spacing, conductor diameter, sub-conductor bundles, audible noise and the safety requirements including electric and magnetic fields, as specified by the International Committee on Non-Ionising Radiation Protection (**ICNIRP**). This process will be described in more detail by Mr Khot and Mr Lake.
31. **IN** the case of the Upgrade Project, the double circuit structure selection was a choice between steel lattice towers and steel monopoles. Transpower selected steel lattice towers as the preferred structure type for the line based on cost. Cost plays a major factor in the Grid Investment Test, and recent Australian experience shows that monopoles are approximately 2.6 times the cost of steel lattice towers of similar strength capabilities. For the overhead line section of the Upgrade Project, and based on the 2.6x factor, the

difference in structure cost would be approximately \$271M for steel monopoles as opposed to \$105M for lattice towers.

32. **THE** initial proposal on which the indicative centreline was published in July 2005 was based on Duplex Rimu AAAC conductor (38mm diameter) to achieve the required 1200MVA per circuit. The conductor, allowable conductor tensions, subsequent tower geometry, tower families, tower height options and clearance requirements were used to define the alignment and tower locations.
33. **THE** design of the alignment and subsequent tower locations was based on three dimensional topographical data obtained by LiDAR (Light Detection and Ranging) in February 2005. This method of aerial survey mapped the terrain providing coordinated laser strikes which were used to create a digital terrain model. Each of the coordinated points was analysed to determine whether they were reflections from the ground, or reflections from objects above the ground (eg trees and buildings). The coordinated points have an absolute accuracy of +/- 0.5m, and a relative accuracy between points of +/- 0.2m.
34. **TRANSPower** obtained coordinated laser data for the complete route width as determined by the ACRE process, plus a further 150m either side of these boundaries. The aerial survey also obtained aerial photography of the route which was geo-referenced, thus allowing the photo to be "draped" over the laser data. An example of this data is shown below.

35. **TRANSPOWER** used PLS-CADD, an internationally accepted transmission line software program to design the proposed line. The aerial survey information and aerial photography was imported into this program to provide a true representation of the ground, vegetation and other constraints. Graphic representation of this program is shown below. Mr Lake will discuss the use of PLS-CADD in more detail.



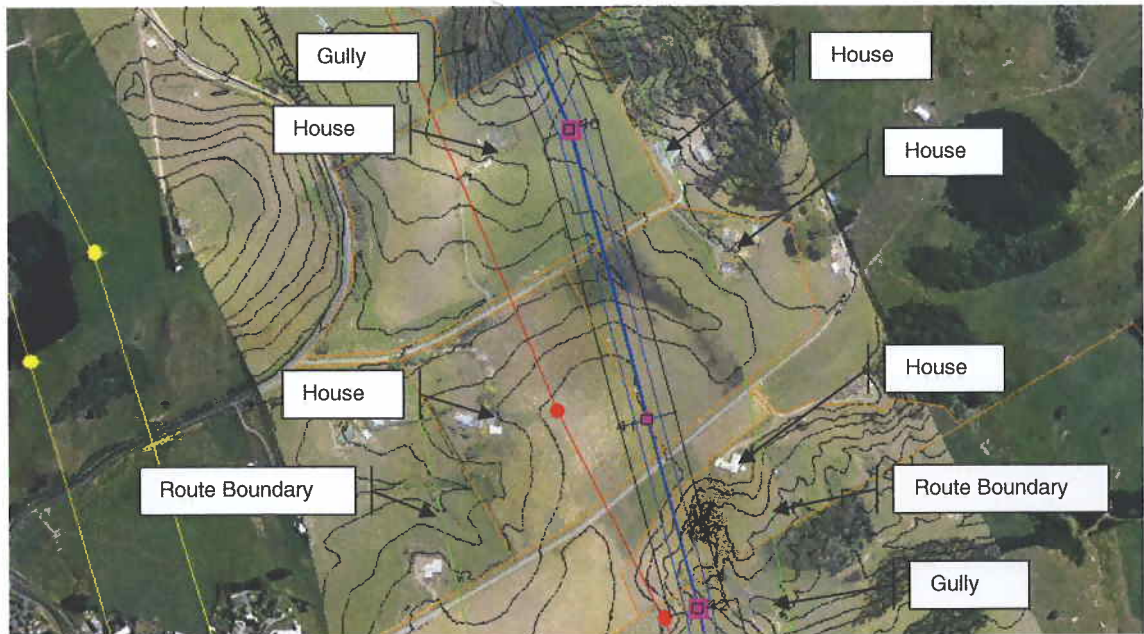
### PRINCIPLES OF ALIGNMENT SELECTION AND TOWER POSITIONING

36. A set of design principles was developed and applied for the initial design that was completed for the indicative centreline study. These principles were taken into account in decisions in the consultation stage that followed. The principles were that:

- (a) The alignment should remain within the route boundaries determined through the ACRE process, unless no further property owners are affected and constraints are avoided;
- (b) Straight, consistent lines are preferred to lines that contain numerous angle changes or where tower heights and spacings vary greatly over a short distance;

- (c) The alignment should follow least visually prominent paths;
- (d) Protected vegetation should be avoided (eg QEII covenants);
- (e) Dwellings should be avoided where possible;
- (f) Effects on the following should be kept to a minimum where possible:
  - (i) outlook from houses;
  - (ii) indigenous vegetation; and
  - (iii) existing buildings;
- (g) Towers should be positioned where they can practically account for landowners' concerns without impinging on the factors above;
- (h) Tower sites should be suitable from an engineering perspective;
- (i) Identifiable benching and earthworks for towers, and tower accesses, should be minimised;
- (j) Topography should be used as much as possible to optimise span lengths while minimising heights of the towers; and
- (k) Specific issues, such as streams, and archaeological sites should be mitigated where necessary.

37. **THE** development of the indicative centreline required a number of iterations and trade-offs between constraints and was done through a workshop involving environment specialists and engineers. The primary objective for the designer at this stage was to optimise the line design, i.e. lowest height towers, maximising span lengths, and avoidance of as many constraints as possible, within the contour of the terrain. An example of constraints being avoided is shown below:



38. **THE** indicative alignment published in July 2005 was designed using desktop analysis, roadside observations and the workshop process. This alignment resulted in a design with the following general characteristics:
- (a) 432 double circuit towers and 6 single circuit towers;
  - (b) 85 structures with an angle  $> 1^\circ$ ;
  - (c) Average Span = 426 metres; and
  - (d) Average Height = 57 metres.
39. **CONSULTATION** was undertaken on the centreline between July 2005 and January 2006. Extensive consultation with landowners through this time, and visits to properties, allowed additional constraints to be identified, as well as site specific information to be obtained. The alignment design went through 6

major revisions through this time that took account of landowner feedback. Tower positions were moved as far as practical to meet landowner concerns, such as placing towers as close to fence lines as possible, moving structures into specific paddocks, avoiding trees of significant ecological value, reducing the number of towers by making them higher (eg one landowner requested 3 towers rather than 4 and was not concerned about height), and mitigating effects on farming patterns. During the consultation stage more than two-thirds of the 432 towers were moved.

**40. THE** easement report, with final tower positions, was published in February 2006 at the completion of consultation. The centreline at this time had the following general characteristics:

- (a) 421 double circuit towers and 6 single circuit towers;
- (b) 82 structures with an angle  $> 1^\circ$ ;
- (c) Average Span = 437 metres; and
- (d) Average Height = 59 metres.

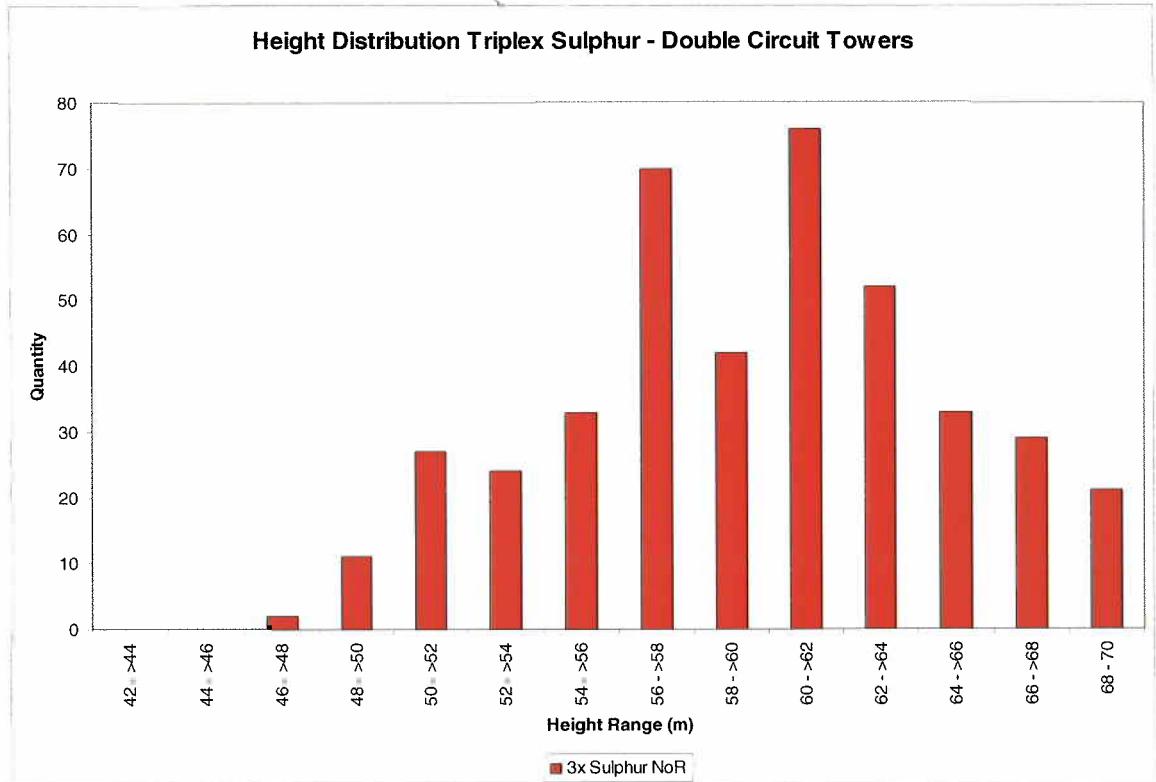
#### **OVERVIEW OF THE PROPOSED LINE DESIGN**

**41. IN** July 2006, Transpower reassessed the required line design for the Upgrade Project. The revised specification called for an increase to 2700MVA per circuit. This increase in capacity led to the selection of Triplex Sulphur AAAC (34mm diameter) conductors as discussed in Mr Khot's evidence. Sulphur AAAC conductor has similar tension and sag characteristics as Rimu AAAC. This ensured the final tower locations identified in the easement report did not need to be modified to meet the change in conductor. The final centreline for the Triplex Sulphur AAAC as lodged in the NORs in May 2007 has the following general characteristics:

- (a) 420 double circuit towers and 6 single circuit towers;
- (b) 81 structures with an angle  $> 1^\circ$ ;
- (c) Average Span = 437 metres; and

(d) Average Height = 60 metres.

42. **MUCH** has been made by the public about 70m high towers along the proposed line. Below is a diagram that graphically shows the distribution of final tower heights. Note that there are 21 towers that are taller than 68m. No tower is taller than 70m.



43. **THE** following section summarises an overall description of the route sections identified in Part VIII, Section 6 of the NOR. This summary includes the general factors influencing the alignment selection, basic structure details of the proposed 400kV capable line (**proposed line**), and the details of the ARI-PAK-A line that is to be removed.

#### Route Section 1 - Whitford Valley (Manukau City Council NOR)

44. **ROUTE** section 1 includes towers 6 to 11. Tower 6 is set by the position of the Brownhill Substation and the need to cross to the east of Carpenters Bush, a reserve of indigenous vegetation in Span 5-6. The alignment follows a straight line from tower 7 to tower 11. The angle point at tower 11 is situated to the

west of Brookby Road in a position where the line can traverse between a cluster of dense housing (see **Appendix A, Figure 1**).

45. **THERE** are 7 towers in the section from tower 6 to tower 11, which range in height from 47m to 62m.
46. **TRANSPower** has taken account of the "*Designation for Auckland International Airport; Specification for Approach and Land Use Controls, Specification for Obstacle Limitation Surfaces*" detailed in Appendix 2B of the Manukau Operative District Plan. Clause 8, Procedure Turning Surfaces, affects the line location and design in the Brookby area.
47. **CLAUSE** 8 specifies: "*The surfaces for the Procedure Turning Areas are at 152 metres above mean sea level or 21 metres above terrain whichever is higher ...*".
48. **TOWER** 9 on the proposed line has been identified as the tower that is nearest to the maximum limitation of this protection surface. Tower 9 has been positioned and designed such that the top of this tower remains below the 152m above mean sea level limit by approximately 0.7m.
49. **THE** section of line to be removed from the ARI-PAK-A line is from tower 419 to tower 441 (24 towers). This section of ARI-PAK-A line follows a more easterly route than the proposed line from Brookby, taking a north-westerly direction to Dannemora. There are road crossings at Brownhill Road, Sandstone Road and Point View Road that will be removed.

#### **Route Section 2 - Brookby Area (Manukau City Council NOR)**

50. **THIS** route section includes towers 12 to 21. Tower 12 is an angle structure located to the east of Brookby Road. The alignment from tower 12 to the top of the Brookby Ridge, 2km to the south, is set by a group of houses, as shown in **Appendix A, Figure 2**, the contour of the terrain, and the required crossing of the Brookby Ridge at a low point. The Brookby Ridge is crossed in the vicinity of tower 16A and tower 16B.
51. **TRANSPower** has taken account of the "*Ardmore Aerodrome Specification for Defining Protection Surfaces*" detailed in Appendix 8 of the Manukau

Operative District Plan. Clause 7, Conical Surface, affects the proposed line location and design in the Brookby Ridge area.

52. **CLAUSE 7** specifies: "*The sloping surface rises upwards and outwards from the periphery of the horizontal surface at a gradient of 5 per cent (1 in 20) for a further 2100 metres until it matches a height of 185 metres AMSL ...*".
53. **TOWERS 14, 15, and 16B** on the proposed line have been identified as the towers that are nearest to the maximum limitation of this protection surface. Towers 14 and 15 have been positioned and designed such that the top of these towers remain below the conical surface at those specific locations by approximately 0.7m. Tower 16B on the Brookby Ridge has been positioned and designed such that the top of this tower remains below the conical surface by approximately 1.0m.
54. **TRANSPOWER** has had the design for the clearances to both the Auckland Airport and Ardmore Protection surfaces independently reviewed by Beca Carter Hollings & Ferner Ltd. The review concluded that the absolute accuracy of the tower heights in terms of the protection surfaces is +/- 0.5m and that all towers therefore clear those surfaces.
55. **THE** next major angle point is tower 17. This angle point is positioned to allow the line to drop from the Brookby Ridge to the Clevedon flats through a valley system. This alignment provides a lower level crossing of the Brookby Ridge than the existing ARI-PAK-A line, the tower positions of which are noted by red markers in **Appendix A, Figure 3**.
56. **TOWER 21** is the next major angle point. This tower is located beside West Road on the South Eastern corner of the Auckland Polo Club's Ryburn Park. Tower 21 has been positioned to provide an alignment that avoids a number of dwellings and a copse of covenanted bush from tower 17. Tower 20 has been positioned to ensure there is a single span crossing over the polo ground (see **Appendix A, Figure 4**).
57. **THERE** are 10 double circuit towers in this section, which range in height from 47m to 66m, and two single circuit towers at the ridge crossing point, which are about 26m high.

58. **THE** section of line to be removed from the ARI-PAK-A line is from tower 407 to tower 418 (12 towers). The ARI-PAK-A line presently passes through a section of covenanted bush in Span 407 to 408, as shown in **Appendix A, Figure 4**. This crossing will be removed, and the cleared swath for the existing line could be allowed to regenerate (subject to the landowner's agreement).
59. **THE** existing ARI-PAK-A 110 kV line traverses the Auckland Airport and Ardmore Protection Surfaces. Towers 412, 413, and 414 on the ARI-PAK-A line that cross the Brookby Ridge currently break the Ardmore Conical Protection Surface by approximately 9.2m, 10.0m, and 29.1m respectively. Tower 414 also breaks the Auckland Airport Procedure Turning Area by 1m.

### **Route Section 3 - Ardmore Basin (Manukau City Council NOR)**

60. **THIS** alignment follows a similar route to that of the ARI-PAK-A line, and includes towers 22 to 33. There are two major angle points in this alignment, located at towers 25 and 30. The angle point at tower 30 near Monument Road is on the eastern side of the existing house rather than the west. This location is to provide equal separation between houses further north, near tower 27 at Tourist Road (see **Appendix A, Figure 5**).
61. **THERE** is insufficient room to locate the easement between the existing house and Monument Road. The position of tower 30 ensures the adjacent house will be outside the easement and could therefore remain in place, as seen in **Appendix A, Figure 6**).
62. **TOWER** 33 is located on the northern side of High Ridge Road. The road runs along the top of a very narrow ridge and there are a number of dwellings near the High Ridge Road / Sky High Road intersection. There are a number of gullies running along the alignment to the north and south of this position (eg towers 30 to 31, and towers 33 to 33A) that have influenced the positioning of tower 33. Tower 33 is to be located in the same position as a dwelling (see **Appendix A, Figure 7**). This dwelling will be either relocated or demolished. Transpower has purchased this property. (Mr Miles will provide evidence about the easement and property acquisition process.)

63. **THERE** are 13 towers in the section from tower 21 to tower 33, which range in height from 50m to 65m.
64. **THE** section of line to be removed from the ARI-PAK-A line is from tower 389 to tower 406 (19 towers). This section is on a similar alignment to the proposed line. The ARI-PAK-A line crossing will be removed from above the house at Monument Road. The ARI-PAK-A line passes through a parallel section of native bush in Spans 389 to 392. This line will be removed, and the cleared swath for the line will be allowed to regenerate (subject to landowner approval).

#### **Route Section 4 - Hunua Basin (Franklin District Council NOR)**

65. **THIS** section includes towers 33A to 45. There are a number of small angles in the alignment in this section of line to ensure constraints are avoided where practical.
66. **THE** angles at towers 36 and 38 provide a straight alignment through a number of dwellings in the White/Jollie Road area. This alignment ensures that all dwellings remain outside the boundaries of the easement, as can be seen in **Appendix A, Figure 8**. Greenhouses to the north of tower 38 and to the north of Sky High Road will be removed from the easement. Transpower has purchased the property where the greenhouses are to be removed.
67. **TOWER** 40 is positioned to provide similar separation distances between dwellings at that location. This also provides clearance to a dwelling to the north at Falls Road, as can be seen in **Appendix A, Figure 9**.
68. **THE** positioning of a small angle at tower 42 takes account of dwellings to the north of this structure, as well as attempting to maximise the distance from the new line to the Hunua School within the route boundaries and identified constraints (see **Appendix A, Figure 10**). The distance from the centre of the proposed alignment to the school property boundary is approximately 260m, and the distance from the centre of the proposed alignment to the nearest school building is approximately 340m. The ground contour in the area of tower 42 is extremely steep and provides little alternative to the final position.

69. **THERE** are 16 towers in section 4, from tower 33 to tower 45, which range in height from 50m to 69m.
70. **THE** section of line to be removed from the ARI-PAK-A line is from tower 372 to tower 388 (16 towers). The ARI-PAK-A line will be removed from above the house at White Road.

**Route Section 5 – South of Hunua Township to South of Lyons Road (Franklin District Council NOR)**

71. **THIS** section includes towers 46 to 71. The angle point at tower 48 is positioned to bring the proposed line to the western side of the route boundary, and within 70m of the existing OTA-WKM-A single circuit 220kV transmission line. The 6.7km section of line from tower 48 to tower 61 runs parallel to the existing OTA-WKM-A transmission line.
72. **THERE** is a high density of lifestyle blocks to the south of Gelling Road. The parallel alignment of the spans between towers 48 and 50 passes over 2 dwellings and an implement shed that will require relocation or demolition to provide a "building free" easement, as can be seen in **Appendix A, Figure 11**. Transpower has purchased all of the properties in this section where relocation of buildings is required.
73. **IN** the Ararimu Road crossing area there is a high density of dwellings, as shown in **Appendix A, Figure 12**. The parallel alignment between towers 55 and 56 passes over a single dwelling that will require relocation or demolition to provide a "building free" easement. Transpower has purchased this property.
74. **THE** route boundary begins to move away from the OTA-WKM-A line in the area of tower 61. The parallel alignment between towers 59, 60 and 61 passes over a single dwelling, a milking shed, and a number of other farm utility buildings, as shown in **Appendix A, Figure 13**. These will all require relocation or demolition to provide a "building free" easement.
75. **THE** alignment in the vicinity of towers 69 and 70 is located as near as possible to the western route boundary in an attempt to maximise the distance

to the Heritage Hotel Du Vin, as well as to reduce the tree clearance across a high value native bush lot near tower 72 (this will be discussed in the next section). The distance from the centre of the proposed alignment to the nearest hotel building is approximately 300m, as shown in **Appendix A, Figure 14.**

76. **THERE** are 27 towers in section 5 from tower 46 to tower 71, which range in height from 50m to 69m.
77. **THE** section of line to be removed from the ARI-PAK-A line is from tower 333 to tower 371 (42 towers). This section of line follows a route through the Paparimu Valley up to 1.5km east of the proposed line. There is one crossing of Hunua Road and two crossings of Paparimu Road that will be removed when the line is dismantled. The ARI-PAK-A line to be dismantled also passes approximately 80m to the east of Paparimu School.

#### **Route Section 6 – South of Lyons Road to Kopuku (Franklin District Council and Waikato District Council NORs)**

78. **SECTION 6** includes towers 71 to 92. The alignment from tower 71 to 77 has allowed a section of high value native bush to be crossed at a narrow point, as shown in **Appendix A, Figure 15.**
79. **THERE** is a small angle at tower 77 to enable the alignment to traverse between a number of houses at the crossing of Mangatangi Road, as shown in **Appendix A, Figure 16.**
80. **FROM** tower 77 the alignment runs along a similar alignment as the existing ARI-PAK-A line for approximately 5.3km to tower 90. Tower 90 is located at an angle point in the route to the east of Maramarua and State highway 2, as shown in **Appendix A, Figure 17.**
81. **THERE** are 20 towers in the section between tower 71 and tower 92, which range in height from 51m to 69m.
82. **THE** section of line to be removed from the ARI-PAK-A line is from tower 307 to tower 332 (29 towers). The ARI-PAK-A line passes through a parallel

section of native bush in Spans 332 to 333. This line will be removed, and the cleared swath for the line allowed to regenerate.

#### **Route Section 7 - Kopuku to Te Hoe (Waikato District Council NOR)**

- 83.** **THIS** section of the alignment is approximately 31km long, and contains towers 91 to 161.
- 84.** **THE** next angle point from tower 90 is located at tower 101, giving a length of line that is approximately 5.3km long. The new section of line follows the same alignment as the ARI-PAK-A line through to Kopuku Road. There are a number of dwellings in the vicinity of Kopuku Road that have been a determining factor in the selection of the final alignment. The location of the angle point at tower 101 has ensured that all dwellings in the vicinity of Kopuku Road remain outside the easement boundary, as shown in **Appendix A, Figure 18**.
- 85.** **THE** next angle point from tower 101 is located at tower 112, giving a straight alignment for approximately 4.2km. This tower is positioned close to the eastern route boundary, as shown in **Appendix A, Figure 19** for a number of reasons including visual, Crown Forest land avoidance, avoiding a house at Awariki Road, and ecological trade-off of effects on bush. These will be discussed in more detail by Mr Lister and Mr Beale. The proposed line crosses over a milking shed, implement shed and concrete feed pad in the vicinity of tower 103 that will all be removed from within the easement. This property has been purchased by Transpower.
- 86.** **THE** next angle point from tower 112 is located at tower 122, giving a straight alignment for approximately 4.4km. This tower is positioned to the south of Waerenga Road in a location that requires the alignment crossing the road to bisect dwellings to the east and west. This alignment runs to the east of, and parallel to, the ARI-PAK-A line at an average separation of approximately 150m, as can be seen **Appendix A, Figure 20**.
- 87.** **FROM** tower 122 the next angle point is located at tower 132, giving a straight alignment for approximately 4.4km. The straight alignment allows the proposed line to pass to the west of a house near tower 124 at Taniwha Road. Tower 132 is positioned to the west of Taniwha Road to provide separation

between a milking shed at tower 131, and a house to the south west of tower 132, as shown in **Appendix A, Figure 21**.

- 88.** **THERE** is a phase transposition site located at towers 140A and 140B, as shown in **Appendix A, Figure 22**. Factors that were taken into account for the selection of this phase transposition site included the distance along the line (approximately a third of the way along the line from Brownhill to Whakamaru), terrain conducive to the phase rolling (equivalent height of conductors from double circuit towers to single circuit towers), and the visual location as will be discussed by Mr Lister. There is a Pa site located 130m to the north-west of tower 141 that has been avoided by this alignment. There is a shearing shed mid-span between tower 137 and 138, and a barn near tower 139 that will need to be removed from the easement.
- 89.** **THE** alignment continues in a southward direction from the transposition site at towers 140A and 140B to a crossing of Matahuru Road. There are a number of dwellings and farm buildings that are bisected by the alignment at this point as shown in **Appendix A, Figure 23**. All of these buildings remain outside the final easement.
- 90.** **THERE** is a major angle at tower 151 that is located to allow optimisation of tower location through very rough terrain to the next angle point at tower 155. The location of tower 151 also ensures that the proposed line avoids an oak tree, as shown in **Appendix A, Figure 24**. **Appendix A, Figure 25** shows the ruggedness of this terrain, with contours set at 5m increments for representation.
- 91.** **THE** alignment of the final segment of section 7 brings the proposed line to the crossing of Mangatea Road, as shown in **Appendix A, Figure 26**. Tower 161 is located approximately 750m south of Mangatea Road and to the west of a hill that contains sites of archaeological significance that will be discussed by Mr Druskovich. The alignment at this road crosses over a milking shed and a number of farm utility buildings that will be removed from the final easement. Dwellings along this road remain outside the easement.
- 92.** **THERE** are 67 double circuit towers in section 7 between tower 91 and tower 161, which range in height from 49m to 69m, and two single circuit towers at the transposition point, which are about 25m high.

